# Apparatus and method for automatically controlling bidirectional printing position in serial printer


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A bidirectional serial printer is described capable of compensating for mechanical errors causing the actual print position to lag behind the estimated position. The position of the printer head is sensed as it is moved in both directions. The position of the printer head is estimated as it is moved in both directions and a mechanical error factor is determined representing the difference between the mechanical error present when the head is moving on one direction and that present when the head is moving in the other direction. In printing, the mechanical errors are compensated by advancing or retarding the firing of the printing head to a degree dependent upon the said mechanical error factors, thus improving the vertical alignment of the printer.


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## Description

### BACKGROUND OF THE INVENTION

The present invention relates to a printing apparatus and method in a bidirectional serial printer.

A serial printer indicates a printer which prints one letter per unit time and generally performs a bidirectional printing. To make the printing speed, the printing operation is performed from left to right of a row, then the printing is performed from right to left in the next row. Accordingly, as the bidirectional printing of the serial printer is performed whenever a carriage is moved, the speed of the bidirectional printing is two times faster than that of the mono-directional printing which the printing operation is performed in only one direction and the next row is printed after the carriage is returned to the starting position.

However, in the case of the above mentioned bidirectional printing, the vertical lines are not properly arranged due to the mechanical error. Accordingly, by using the printer aligning software the printing position error can be corrected.

Referring to FIG.1, there is shown an actual printing position caused by the mechanical error and a printing position sensed by the software, and there are also shown the printing positions after performing vertical alignment. In the drawing, when the carriage is moved from right to left, C indicates the printing position sensed by the central processing unit of the system operating the printing software, and A indicates an actual position printed by the mechanical error. In the next row, when the carriage is moved from left to right, C indicates the printing position sensed by the central processing unit of the system operating the printing software, B indicates the position which is actually printed by the mechanical error, and D indicates the distanced difference between the actual printing positions A and B. In addition, when the carriage is moved from left to right (to R direction), B' indicates the printing position where the head fire time is delayed as much as the time period corresponding to the distance difference D of the actual printing positions A and B.

When aligning the vertical line for printing B by delaying as much as the distance difference D of the two actual printing positions A and B of FIG.1, the error of the horizontal printing position indicated when the bidirectional printing is corrected by the initial controlling when producing the printer and by using the vertical alignment controlling function. That is, the operation is performed in the following orders.

First, as shown in FIG.2, in order to get the test printing results for vertical alignment, the test printing for vertical alignment is performed. The printing results (1) to (6) of FIG.2, are obtained through the different vertical alignment value allocated by the printing aligning software. The vertical alignment is finished by selecting the number (4), which has the most arranged vertical line out of the numbers (1) through (6). Here, the vertical alignment value indicates a value for compensating for the difference between the position of the actual mechanical driving unit generated by the mechanical error and the position sensed by the central processing unit of the system. By delaying the fire time of a printer head, the printing operation is performed. That is, when the user of the printer selects a number having the most arranged vertical line, the printer system converts the distance value corresponding to the distance different D to FIG.1, into the time value and performs the printing operation by delaying the fire time of the printer head, thereby achieving the aligning operation. In the case of the above mentioned conventional method which is aligning the printing position according to the printing results provided by the printer aligning software, as the accuracy of the aligning results is influenced by the interval of the shift values between the actually selected number and its fore or back number, it is impossible to control minutely.

Accordingly, when performing the vertical alignment in the conventional invention, as the printed results are confirmed with a naked eye, the accuracy cannot be trusted and the skill of the operator influences the quality. As the operations of confirming the printed materials, controlling the compensating value, confirming the printed results, re-control, etc. are repeated, it takes much time and efforts to align the accurate vertical line. Additionally, although the number is chosen most properly, in the case that a proper value exists between the most proper number and the next number, it has a problem in that it is impossible to perform the minute control more than the predetermined resolution.

Therefore, it is an object of the present invention to provide an improved printer and control method which reduces image misalignment in bidirectional printing.

### SUMMARY OF THE INVENTION

To achieve the above mentioned object, a bidirectional serial printer according to the invention comprises a reciprocating printer head, sensing means for sensing the position of the printer head as it is moved in both directions, error detecting means for estimating the position of the printer head as it is moved in both directions and determining one or more mechanical error factors representing the difference between a mechanical error present when the head is moving on one direction and a mechanical error present when the head is moving in the other direction, the mechanical error being the difference between the sensed position of the printer head and the estimated position of the printer head, and printing means for compensating for the said mechanical errors by advancing or retarding the firing of the printing head to a degree dependent upon the said mechanical error factors, thus improving the vertical alignment of the printer.

The sensing means may include a transmitting part

attached to a reciprocating carriage upon which the printer head is mounted, and a receiving part attached to a main frame of the printer which is adapted to sense a signal transmitted by the transmitting part. Alternatively, the sensing means may include a transmitting part attached to a main frame of the printer and a receiving part attached to a reciprocating carriage upon which the printer head is mounted and which is adapted to sense a signal transmitted by the transmitting part.

Preferably, the error detecting means includes means for storing a head fire position HFP and a fire time delay FTD count when the transmitted signal is sensed by the receiving part with the carriage moving in one direction, means for storing a head fire position HFP and a fire time delay FTD count when the transmitted signal is sensed by the receiving part with the carriage moving in the other direction and position difference operating means for calculating the said one or more mechanical error factors from the stored HFP and FTD count values.

The means for storing a head fire position HFP and a fire time delay FTD count may includes adjacent position determination means for determining whether the estimated head position has reached the head fire position HFP corresponding to a first adjacent position, counter operating means for initialising a fire time delay FTD counter when the estimated head position has reached the head fire position HFP corresponding to the first adjacent position and starting the operation of the counter, head fire position increase determination means for determining whether the value of the fire time delay FTD count exceeds a head fire position value and, if so, incrementing the HFP and resetting the FTD counter, sensing determination means for determining whether the signal from the transmitting part of the sensor is sensed by the receiving part; and storing means for storing the head fire position HFP when the said signal is sensed by the said receiving part and storing the fire time delay FTD count.

The means for storing a head fire position HFP and a fire time delay FTD count preferably includes adjacent position determination means for determining whether the estimated head position has reached the head fire position HFP corresponding to a second adjacent position, counter operating means for initializing the fire time delay FTD counter when the estimated head position has reached the head fire position corresponding to the second adjacent position and starting the operation of the counter, head fire position HFP increase determination means for determining whether the value of the fire time delay counter exceeds a head fire position value and, if so, incrementing the HFP and resetting the FTD counter, sensing determination means for determining whether the signal from the transmitting part of the sensor is sensed by the receiving part and storing means for storing the head fire position HFP when the said signal is sensed by the said receiving part and storing the fire time delay FTD count.

Means for controlling the motion of the printer head may be provided, including return position determination means for determining whether the estimated position of the printer head has reached a head fire position HFP corresponding to a return position and moving means for moving the carriage reversely when that condition is met.

The means for controlling the motion of the printer head may including start position determining means for determining whether the estimated position of the printer head has reached a head fire position HFP corresponding to a start position and stopping means for stopping the carriage when that condition is met.

The position difference operating means may calculate a head fire position HFP difference and a fire time delay FTD difference using the stored HFP and FTD values.

Preferably, the printing means includes clock generating means for generating a clock, print starting signal generating means for generating a print starting signal by determining the estimated position of the printing head using the clock signal generated by the clock generating means and enable signal generating means for generating an enable signal by determining the correct printing time in compliance with the fire time delay FTD difference using the clock generated by the clock generating means.

The print starting signal generating means may include DPI dividing means for dividing the clock according to the DPI (Dot Per Inch) supported by the serial printer system, head time dividing means for dividing again the divided clock to generate the standard clock frequency per nozzle from the clock divided by the DPI dividing means, a head time counter for counting the head time based on the clock divided by the head time dividing means, a first comparator for generating a head fire standard clock by comparing the value counted by the head time counter with a predetermined value, position dividing means for generating a clock for controlling operation of the printer motor using the clock generated by the clock generating means, a position up/down counter for performing a counting operation to seek the present position of the printer head using the clock divided by the position dividing means, a second comparator for detecting the estimated head position using the said predetermined value, a head fire position HFP difference input means for receiving the calculated difference of the head fire position HFP and a third comparator for generating the printing signal delayed by as much as the head fire position HFP difference by comparing the value of the estimated head position with the head fire position HFP difference stored in the print starting position register.

The enable signal generating means may include resolution dividing means for dividing the clock generated by the clock generating means according to the printing resolution, a fire time delay FTD counter for counting the clock divided by the resolution dividing